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METHODS AND INTERPRETATION OF WATER ANALYSIS.

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The average consumer judges of the quality of the drinking water by means of his special senses of sight, smell and taste. Water which is turbid or emits a disagreeable odor is unreservedly condemned, while clear, sparkling water free from odor is just as unqualifiedly pronounced "pure." Those of us who are familiar with the history of typhoid epidemics and have had opportunity to examine drinking waters by means of special methods know how fallacious such a crude judgment is. Water that is clear and sparkling may contain the germs of typhoid fever or may be polluted with sewage which, in the course of decomposition, gave rise to carbonic acid. It takes many billions of bacteria to render a glass of water perceptibly turbid, and it requires considerable fresh sewage to impart to it a fecal odor. On the other hand, a turbid water, although objectionable from an esthetic point of view, may be entirely wholesome, and a disagreeable odor may be due to inoffensive vegetable compounds or harmless algae.

This evident inability to form a ready judgment of the quality of a drinking water has led the sanitarian to seek the aid of the chemist, who, it was supposed, could readily detect by means of chemical analysis the injurious substances in the water under suspicion. However, it soon became evident that a chemical analysis of water for sanitary purposes differs essentially from any other kind of

analysis which the chemist may be called upon to make. The finding of arsenic or some poisonous alkaloid in a suspected fluid is decisive, and a report on such finding is merely a statement of fact. In the analysis of water, on the other hand, the findings are purely relative and must be properly interpreted before they can be of any value. A drinking water, if I may borrow the legal phraseology, is indicted on circumstantial evidence, and it depends on the erudition and ability of the chemist to so interpret and connect the evidence as to make out a clear case for or against the suspected water.

The object of a chemical analysis of water is to discover whether or not pollution with objectionable organic impurities has taken place. By "objectionable organic impurities" we understand those which are from human or animal sources and are capable of conveying the germs of disease. In other words, we look principally for fecal contamination, inasmuch as the germs of typhoid fever, cholera, dysentery and other intestinal disorders are excreted with the feces and together with the feces gain access to the water. By itself, organic matter in the minute quantities in which it is present in water, is not injurious to health, even if derived from sewage. It is only because this organic matter may be the carrier of disease germs that it becomes a matter of serious consideration. Therefore, organic matter derived from plants or vegetables removed from the possibility of infection with disease-producing bacteria has no significance from a sanitary standpoint, and its presence in drinking water in no way renders it unwholesome.

It is thus evident that the aim of the sanitary chemist is to discover, first, the presence of organic matter, which would indicate pollution, and, second, to determine the source of this organic matter. How well these two requirements are fulfilled by a chemical analysis will be made clear later.

Dead organic matter in water, as elsewhere, is not in a state of stability. Through the agency of certain bacteria, in the presence of oxygen, it continuously undergoes material changes, becoming resolved into simpler inorganic compounds. The nitrogenous substances are converted into ammonia, and the latter into nitrous and finally nitric acid, the two acids combining with bases usually present to form nitrites and nitrates, respectively. These changes may be best illustrated by the following scheme:

Organic matter { Carbon—Carbon dioxide. / Hydrogen, Nitrogen { Ammonia { Nitrous acid (Nitrites), Water } } Nitric acid (Nitrates).

This process, may it be remarked in passing, is a beneficial one, since by its means purification of polluted water is accomplished and the decaying organic matter converted into useful plant food.

These changes, under favorable conditions, take place incessantly so long as there is a supply of dead organic matter and the necessary bacteria are present. Therefore, the amount of organic matter in water represents that portion which has not yet undergone disintegration—the organic nitrogen or so-called albuminoid ammonia—as well as the various intermediary products of the portion which has undergone or is undergoing disintegration—free ammonia, nitrites and nitrates. The quantitative relation of these products of oxidation to each other as well as to the unoxidized nitrogenous matter will depend on the original amount of the organic matter and the rapidity with which oxidation has taken place. Therefore, an analysis which discloses these various stages of oxidation reveals also not only the presence but the retrogressive course of the organic matter. Given a water containing relatively large amounts of albuminoid and free ammonia, together with nitrites and nitrates, the indications would be that such water contains a large amount of organic matter in a state of incomplete oxidation; in other words, the contamination is recent. On the other hand, the presence of nitrates, in the absence of nitrites, with only small amounts of free and albuminoid ammonia, would indicate complete oxidation or a previous pollution. It goes without saying that pure water should contain only traces of albuminoid and free ammonia and should be free from nitrites and nitrates, the latter, if in small quantity, being rapidly appropriated by the water plants. It is to be expected that in deep wells removed from the possibility of pollution, the water will contain very slight amounts of ammonia and no nitrites or nitrates, or mere traces, although free ammonia may sometimes be present in large amounts as a result of oxidation of vegetable matter or nitrates by ferric oxide.

In addition to organic matter, water contains various salts, the most important and constant of which is sodium chloride or, occasionally, magnesium and calcium chloride. These chlorides are derived from the sea or geological formations rich in salts. The

amount of chlorides will vary with the natural source and remains fairly constant. However, when the water is polluted with sewage or household refuse the chlorides will increase in proportion to the degree and nature of the pollution, and this increase serves as a reliable indication of past or present pollution. This index, however, is of value only when the normal chlorine contents of the water in question or of waters in the immediate neighborhood is known.

On the foregoing considerations are based the various methods employed in the chemical analysis of water. As these methods are fully described in books on the subject, I shall not dwell on them here, but will mention the modifications which I found useful in my work. For the determination of turbidity, free and albuminoid ammonia, nitrates, nitrites and iron I employ Jackson's standards, which are used in the Mt. Prospect Laboratory, Brooklyn, and are described by Mr. Jackson in the *Technology Quarterly*, Vol. XIII, No. 4, 1900. A constant use of the standards convinced me of their accuracy and convenience. They offer the great advantage of being always on hand and presenting a uniformity of composition (color) not attainable when the standards are made up extemporaneously. However, in the determination of turbidity I depart somewhat from Mr. Jackson's recommendations and make use of 100 c.c. xx tincture bottles, glass stoppered (W. T. & Co.), instead of 100 c.c. Nessler tubes. I found that by means of these bottles it is possible to determine the turbidity with much greater accuracy. In determining nitrates and nitrites I treat 200 c.c. of the water with an excess of precipitated and washed aluminum hydrate, decanting the clear supernatant fluid. This brings about complete decolorization of the water, a condition most desirable in the case of surface waters which are frequently colored, the color interfering with the proper determination of nitrites and nitrates. I do not determine the loss on ignition for the reason that it is not a reliable method of determining the organic matter in the residue. When the latter is subjected to heat, the nitrates are decomposed and the chlorides volatilized to a considerable extent, while some salts retain the water of crystallization despite the heating. The loss on ignition, therefore, does not represent the amount of organic matter burned. I do, however, heat the residue, but only to observe the charring on ignition. The degree of charring of the residue does indicate, roughly, of course, the amount of organic matter.

UNRELIABILITY OF CHEMICAL DATA.

There are a number of serious objections to the data obtained by a chemical analysis. (1) Excessive free ammonia in ground waters may be the result, as has been mentioned, of the oxidizing action of iron or other metals on the nitrates present, while in surface waters it may be produced by the action of a fungus Crenothrix (Brown). (2) The nitrites found in deep-well water may be the result of the reduction of nitrates normally present in the soil and, consequently, in no way represent organic pollution. One of the chief objections, however, is that a chemical analysis does not reveal the nature of the organic matter, whether of vegetable or animal origin. Admitting that a certain water contains an excess of organic matter, the question arises, Does this organic matter represent harmless vegetables or dangerous sewage? The chemist cannot answer this question with a certainty which would preclude a "reasonable doubt." Yet a water contaminated even with large amounts of vegetable matter, while not the best kind of water to drink, is, nevertheless, free from danger. It is true, that if the ammonia on distillation is given off rapidly and the nitrites and chlorine are excessive, the indications that the organic matter is derived from sewage are reasonably clear, but the rapidity with which ammonia even from animal matter is given off is only comparative and there is no way of gauging it, while the excessive amount of chlorine as compared with the normal chlorine standard of that particular locality presupposes a previous study of unpolluted waters which is seldom made and which often cannot be made.

The other objection, one of a much more serious nature, is that water may be organically pure and yet contain germs of disease. Instances are cited by a number of authors showing that water-supplies pronounced on chemical evidence to be above suspicion have been proved to have caused serious epidemics of typhoid fever or dysentery. Thus Dr. Thresh, in his well-known book on "Water and Water Supplies," cites a number of such instances, a few of which I will quote.

The water from the river Ouse, below where it receives the sewage of Buckingham, to which an epidemic of typhoid fever was attributed, was analyzed by the public analyst, who reported that it "does not appear from the analysis to contain sewage matter."

The Beverley water-supply, which became polluted with infected sewage from an asylum, giving rise to a typhoid epidemic, was pronounced by the chemist to be "of a very high degree of purity, and eminently suitable for drinking and domestic purposes."

Analysis of water from the sewage-polluted Trent showed that "there is no evidence of the product of sewage contamination."

The well-water supplying Houghton-le-Spring became contaminated with sewage from a farm, causing a sudden outbreak of typhoid fever. The chemist who analyzed the water reported that "this water is very free from indications of organic impurity. . . . It is a good water for drinking purposes."

The reason for this evident failure on the part of the chemist to detect dangerous pollution is not difficult to find. A generally pure water may become contaminated with an amount of sewage too small to give evidence of its presence when diluted with several million gallons of water, yet this small amount of sewage may contain numerous specific germs the presence of which cannot be detected by a chemical analysis. Again, the sewage may have undergone complete oxidation and the end products taken up by the plants, leaving no perceptible evidence of the pollution, while many of the specific germs which may have been present in the original sewage remain viable and capable of causing disease.

Before leaving this phase of the subject, I wish to point out the value of chemical analysis in comparing different waters in the same locality or a certain water at different times. In this connection, the data obtained by a chemical analysis are both accurate and valuable. Also in the study of filtration, especially of the slow-sand type, chemical analysis of the raw water and effluent made from time to time furnishes valuable evidence of the efficiency of the filter in removing turbidity and color, and bringing about the nitrification of organic matter which is the essential feature of this process of water-purification.

BACTERIOLOGICAL EXAMINATION.

With the advent of bacteriology, and especially after the introduction of Koch's plate method of isolation of bacteria, the hope of the sanitarian had been revived. It was supposed that at last we have a method by means of which we may detect the specific causes of disease in water, and thus place the examination of water on the

same certain basis as the detection of poisons. With the knowledge that typhoid fever is usually caused by the drinking water and after the discovery by Koch that cholera is of similar origin, it was expected that the typhoid bacilli and the cholera spirilla could be detected in the suspected water. Unfortunately, disappointment followed all attempts in this direction. It soon became evident that while a certain water has been the cause of either a cholera or typhoid epidemic, as established by all evidence at hand, neither the cholera spirillum or the typhoid bacillus could be detected in such waters. The cause for this failure was found in the great predominance of water bacteria which overgrow and obscure the few specific parasites, rendering their discovery impossible. The effort may be compared to looking for a needle in a haystack. While not entirely abandoned, the search for specific microorganisms has not been made the object of routine examinations; and until some satisfactory method is devised by which the saprophytic bacteria may be entirely eliminated and the number of the specific microorganisms increased so as to have them present in very small quantities of the water, the bacteriologist must depend upon other data upon which a conclusion as to the quality of the water may be reasonably based. It was thought for a time that the number of bacteria in the water could serve as an index of pollution, and a number of standards of bacterial purity have been suggested by various authorities. Thus, Koch considers 100 bacteria per cubic centimetre as the safe limit for drinking water; Miquel raises the standard to 1,000; Crookshank agrees with this standard, while Macé and Migula claim that 250 to 500 bacteria is the highest limit for a good drinking water. These or any other arbitrary standards based on mere number of bacteria are as fallacious as the "standards" proposed from time to time for ammonias, nitrites, nitrates, etc. In the first place, the number of bacteria in water will vary greatly with the medium, the reaction of the medium, the length of time the colonies are allowed to develop, dilution, etc., as may be seen by the following data:

(1) *Time of Plating.*—It makes considerable difference whether the water is plated immediately upon collection or is allowed to stand for some time before plating. At room temperature, the bacteria multiply enormously, so that if the plating is done several hours after collection of the sample, an originally pure water may be condemned on the bacterial count. On the other hand, if packed in

ice, the bacteria decrease in number sometimes to a very marked degree. This is clearly shown by Jordan and Irons (*Trans. Am. Pub. H. Ass.*, Vol. XXV, 1899) in the following table:

	A.		B.		C.	
	Temp. C°.	No. Bacteria per 1 c.c.	Temp. C°.	No. Bacteria per 1 c.c.	Temp. C°.	No. Bacteria per 1 c.c.
Immediately after collection . .	20'75	176	23'5	950,000	29	385,000
After 3 hours	9	123	9	510,000	29	. . . . .
" 6 "	6	93	6	90,000	(4 hrs.) 66	130,000
" 11 "	8	87	6	430,000	(8 hrs.) 2	210,000
" 24 "	7	72	7	380,000	(22 hrs.) 6	136,000
" 32 "	8	46	8	340,000	. . . . .	. . . .
" 49 "	4	27	2'5	429,000	(46 hrs.) 8	305,000
" 72 "	1	39	3'5	480,000		

This marked decrease the authors ascribe to the effect of sudden chilling.

(2) *Dilution.*—It is by no means a matter of indifference whether the water is plated as it is or diluted; also the degrees of the dilution employed has an effect on the number of bacteria per 1 c.c., as shown by Jordan and Irons (*l. c.*) in the following table:

A.		B.	
Undiluted	218	Diluted 1–1,000	844,000
Diluted 1–10	470	Diluted 1–10,000	2,630,000
. . . . .		Diluted 1–100,000	4,300,000
C.		**D.**	
Undiluted	1,500	Diluted 1–1,000	479,000
Diluted 1–10	4,340	Diluted 1–10,000	1,120,000
Diluted 1–100	8,800	Diluted 1–100,000	1,300,000

This variation in number, dependent on dilution, is due to the obscuration of colonies through inhibition of growth when undiluted water is plated. In the matter of dilutions, the number and vigor of shakes to which the vessel is subjected before the 1 c.c. is with-

drawn affects the numerical results, also whether distilled or tap-water is used as a diluent. The method I employ is to have on hand 50 and 100 c.c. graduated flasks half-full of tap water. These are sterilized in the autoclave. One cubic centimetre of the water is added to either the 50 or 100 c.c. flask, and contents subjected to ten vigorous shakes. The flask is then filled to the mark with sterile tap-water and inverted twenty-five times. If higher dilutions are required portions of diluted water are similarly treated.

(3) *Composition of Media.*—That the constituents, reaction and character of the medium influence the number of bacteria to a very great extent is a well-known fact attested by numerous experimental data. The marked variations in the number of bacteria in the same water plated on different media is shown by the following data obtained by Jordan and Irons (*l. c.*):

(1) SURFACE WATER (LAKE MICHIGAN).

	Reaction (Fuller's scale).	No. of Colonies. Eight days.
Ordinary Witte's peptone agar	+10	50
Ordinary Witte's peptone gelatin	+10	130
Somatose gelatin (no broth)	0	110
Nährstoff Heyden gelatin (no broth)	0	460
Somatose agar (no broth)	0	470
Nährstoff Heyden agar (no broth)	0	570

(2) SURFACE WATER (MISSISSIPPI RIVER).

	Reaction (Fuller's scale).	No. of Colonies. Seven days.
Ordinary Witte's peptone agar	+10	206
Somatose agar (no broth)	0	543
Nährstoff Heyden agar (no broth)	0	612

(3) SEWAGE (DILUTED $\frac{1}{10000}$).

	Reaction (Fuller's scale).	No. of Colonies. Ten days.
Witte's peptone agar	+10	127 127
Somatose agar	0	198
Nährstoff Heyden agar	0	355 342

(4) GROUND WATER (ARTESIAN WELL).

	Reaction (Fuller's scale).	No. of Colonies. Nine days.
Ordinary Witte's peptone agar	+10	15
Ordinary Witte's peptone gelatin	+10	21
Nährstoff Heyden gelatin	0	700
Somatose agar	0	584
Nährstoff Heyden agar	0	920

Equally marked variations were obtained by Gage and Phelps (*Centralbl. f. Bakt., Paras. u. Infek.*, Abt. 1, Bd. xxxii, No. 12, 1902; *Trans. of the Am. Pub. H. Ass. of the Twenty-ninth Annual Meeting*, 1901). They experimented with thirteen different media and various waters. Fuller and Johnson (*Trans. Am. Pub. H. Ass.*, Vol. XXV, 1899) experimented with a medium composed of meat infusion and 12 per cent. gelatin, omitting the peptone and salt, with the following comparative results:

NUMBER OF BACTERIA PER CUBIC CENTIMETRE.

Reaction (per cent).	Regular Nutrient Gelatin.	Meat Infusion and Gelatin.
0·0	110	200
0·5	110	210
1·0	120	100
1·5	80	130
2·0	75	70

This table also shows the effect of the reaction. The optimum reaction in this case was + 0·5 for the meat infusion gelatin and + 1·0 for the regular nutrient gelatin. The optimum reaction, however, will differ with different waters. Generally + 10 to + 15 (Fuller's scale) is recommended. In my own experimental work I found equally striking variations as shown in the table, page 111.

The gelatins Nos. 1 and 9 were prepared according to the directions given by the Laboratory Committee of the American Public Health Association on Standard Methods. Gelatin No. 2 was prepared in accordance with the same method, with the exception that Armour's extract of beef was used instead of meat. The reaction in each case was + 15. An extended series of observations on the Gelatins Nos. 1 and 2 showed that the latter invariably gave twice the number of bacteria.

(4) *Condition of Cultivation.*—An atmosphere saturated with moisture, as shown by Whipple (*Technology Quarterly*, Vol. XII, No. 4, December, 1899), favors a greater development of bacteria. The temperature also plays an important role, since fewer bacteria will develop at 10° C. than at 20° C. The difficulty of maintaining a constant low temperature is well known.

(5) *Length of Cultivation.*—The day on which the colonies are counted influences the numerical results, perhaps, more than any

Series.	Medium.	Day of Count.	No. Bacteria per 1 c.c.
A	Gelatin No. 1	2	3,000
	" " 2	2	8,000
	Nährstoff Heyden agar	10	55,000
B	Gelatin No. 1	2	10,000
	" " 2	2	24,000
	Nährstoff Heyden agar	10	30,000
C	Gelatin No. 2	2	87,000
	Nährstoff Heyden agar	10	172,000
D	Gelatin No. 2	2	70,000
	Nährstoff Heyden agar	10	108,000
E	Gelatin No. 1	2	8,000
	" " 2	2	14,000
	Nährstoff Heyden agar	10	53,500
F	Gelatin No. 1	2	2,350
	" " 2	2	4,800
	" " 9	2	2,150
	Nährstoff Heyden agar	10	8,850
G	Gelatin No. 1	2	2,050
	" " 9	2	4,750
	Nährstoff Heyden agar	10	34,500

other factor. Given a certain medium and environment, some species of bacteria will develop more rapidly than others. I could illustrate this fact by numerous instances, but will cite only a few from my own records:

Gelatin plates,	third	day	count	3,050
" "	fourth	"	"	5,350
" "	third	"	"	4,750
" "	fourth	"	"	12,150
" "	second	"	"	8,000
" "	third	"	"	50,000
" "	second	"	"	2,350
" "	sixth	"	"	4,500
" "	second	"	"	4,800
" "	sixth	"	"	13,150

Gelatin plates,	second	day	count	2,150
"	sixth	"	"	7,350
"	second	"	"	2,050
"	sixth	"	"	11,000

The committee of the American Public Health Association on Standard Laboratory Methods recommends that plates be counted on the second day. The difficulty, however, of establishing a uniform practice lies in the variability of saprophytic bacterial species not only in different waters, but in the same water at different times. Thus a certain water may contain species which develop rapidly at 20° C., while another water, or the same at another time, may contain species which develop slowly at that temperature. As a matter of fact, waters containing large numbers of bacteria whose optimum temperature is 37° C. (fecal and other pathogenic organisms) will show a lower count, owing to the fact that these species develop slowly at 20° C., and the colonies could be readily overlooked on the second day count. In the case of testing the efficiency of a filter, the difficulty is augmented by the fact that the raw water does not contain, in point of numbers, the same species as does the effluent. On the other hand, prolonging the final count to the third or fourth day endangers the integrity of the gelatin plate, which often becomes liquefied at the end of the second day, unless kept at a temperature lower than 20° C., when the error, occasioned by a still lower temperature, is introduced.

The investigations of others, as well as my own, demonstrate conclusively that Nährstoff Heyden agar permits the development of the maximum number of bacteria, very likely all the bacteria found in a given quantity of water. This medium, according to Hesse and Niedner, who were the first to suggest it (*Zeitschr. f. Hyg.*, Vol. XXIX, p. 454) is prepared as follows:

	Per cent.
Agar-agar	1.25
Nährstoff Heyden	0.75
Distilled water	98.00

The Nährstoff Heyden, which is an albumose, is dissolved in water, mixed with the agar and the whole boiled until the agar is completely dissolved. It may then be filtered through absorbent cotton. The medium requires no adjustment of reaction, nor any other manipulations which, in the case of other media, interfere with the uniform composition of the finished product. Nährstoff Heyden

agar is of uniform composition, and offers the additional advantage that the colonies developing on it never spread nor grow so large as to obscure their smaller neighbors. The plates are usually counted on the ninth or tenth day, although the count may be made on the fifth or sixth day without any great error being introduced. The colonies developing on this medium are, as a rule, not characteristic, but chromogenesis is brought out remarkably well. A plate containing a number of chromogenic species looks like a field bedecked with early spring flowers. It is quite likely that this medium may prove of great use in the grouping of bacterial species according to chromogenesis.

But even if in Nährstoff Heyden agar we possess a medium which will show all the bacteria found in a given sample of water, we are still unable to pass definite judgment on its hygienic quality. After all, the number of bacteria in water indicates the presence of bacterial food, or organic matter, but does not reveal to us the nature of that organic food, whether of vegetable or animal origin. Therefore, the same objection that is raised against the chemical analysis of water pertains with almost equal force to the mere counting of the number of bacteria. To remedy this defect, bacteriologists introduced the presence or absence of B. coli communis, a normal resident of the intestinal tract of man and animals, as the criterion for the presence or absence of fecal pollution. The presence of the B. coli communis indicates the presence of feces, and the contamination with the latter makes it possible for the typhoid bacilli to be present. Consequently, the investigation of water supposed to have been the cause of a typhoid epidemic rests on the presence of the colon bacillus as the indirect but certain evidence. However, the mere presence of the colon bacillus, which is so widely spread in nature, is no certain indication of fecal pollution, unless the number of B. coli is large. Unfortunately, the methods for the enumeration of this microorganism are either too complicated for routine work or inaccurate; and, besides, bacteriologists are not quite agreed as to what constitutes a genuine B. coli communis, there being a number of species not found in feces which closely resemble it.

It would seem from the foregoing considerations that we possess no certain means of detecting dangerous pollution in cases in which a mere sanitary inspection does not make the source of the pollution evident (proximity of privy, discharge of sewage into the stream, etc.).

Fortunately, however, this is not the case. While it is true that no single factor establishes definitely the character of the water under suspicion, a combination of factors with their proper grouping and interpretation is capable of forging a chain of evidence, placing the verdict "beyond a reasonable doubt." The procedure, which will yield satisfactory results, is as follows:

The water is subjected to a chemical analysis, and an adequate portion, 1 c.c. or a fraction of a cubic centimetre, plated in gelatin, Nährstoff Heyden agar, litmus lactose agar, carbolic acid lactose agar and neutral red lactose bouillon.[1] The carbolic acid lactose agar is made by the addition to 5 c.c. of the medium of 0·05 — 0·1 c.c. of Parietti's solution (hydrochloric acid 4 c.c., 5 per cent. carbolic acid solution 100 c.c.). The neutral red lactose bouillon is made by adding 10 c.c. of a 1 per cent. solution of neutral red to 1 litre of lactose bouillon (1 per cent.). The gelatin and Nährstoff Heyden plates are kept at 20° C., and the others at 37° C. The gelatin plates are counted at the end of two days, the Nährstoff Heyden agar plate at the end of nine days, the litmus lactose agar plate at the end of twenty-four hours and the carbolic acid lactose agar plate at the end of forty-eight hours.

Interpretation of Results.—By using these several media we aim to demonstrate: (1) The presence of organic pollution by the combined chemical analysis and bacterial count, the count on gelatin serving as a comparate with the counts obtained by other observers who have used gelatin, while the Nährstoff Heyden agar shows the total number of bacteria.

(2) The presence and number of bacteria which develop at 37° C. and the presence and number of red colonies which may be either B. coli communis, Houston's streptococcus or some other sewage organism producing acid. This information is furnished by the litmus lactose agar plate.

(3) The presence and number of bacteria which resist the addition of carbolic acid, as B. coli communis or some other equally resistant microorganism which could not be an ordinary water saprophyte. This is indicated by the carbolic acid lactose agar.

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[1] The neutral red lactose bouillon was suggested by Dr. Stokes, of the Baltimore City Board of Health, at the meeting of the American Public Health Association, at Washington, D. C., 1903.

(4) The absence or possible presence of B. coli communis as indicated by the production or non-production of gas and characteristic reaction with the neutral red dye.

Given a water which shows on chemical analysis organic pollution and which shows a large number of bacteria on gelatin and a considerable number of bacteria on the litmus lactose agar and Parietti's solution lactose agar plates together with red colonies on the former and production of gas plus characteristic reaction with the neutral red in the neutral-red lactose bouillon, such a water may be pronounced polluted with sewage, beyond a reasonable doubt.

The practical application of this method is illustrated in the following instance.

Water from the race carrying Brandywine water was examined with the following results (in 1 c.c.):

No. of bacteria on gelatin, second day count	1,000
" " " " Nährstoff agar, tenth day count	9,000
" " " " litmus lactose agar, twenty-four hours	57
" " red colonies (proved to be B. coli)	8

Neutral red lactose bouillon (1 c.c. of water), typical reaction.

At the same time the water from the Cool Spring Reservoir, containing the same water, was examined and showed (in 1 c.c.):

No. of bacteria on gelatin, second day count	3,400
" " " " Nährstoff agar, tenth day count	75,000
" " " " litmus lactose agar, twenty-four hours	26
" " " " red colonies	1

Neutral red lactose bouillon (1 c.c. of water) showed production of gas without characteristic change of color.

Subsequent study of the single red colony showed that it belonged to the proteus group.

At another time the race-water showed (in 1 c.c.):

No. of bacteria on gelatin	13,000
" " " " lactose litmus agar	97
" " red colonies (proved to be B. coli)	33
" " bacteria on carbolized lactose agar	46

Neutral-red lactose bouillon, typical reaction.

The water from the reservoir showed (in 1 c.c.):

No. of bacteria on gelatin	16,350
" " " " lactose litmus agar	37
" " red colonies (proved to be B. coli)	7
" " bacteria on carbolized lactose agar	37

Neutral-red lactose bouillon, typical reaction.

The Brandywine water is an extremely polluted stream, receiving the sewage from Coatesville and other places. The water in the reservoir receives but little sedimentation and is drawn near the bottom. We would expect, then, that the water from the reservoir would contain more saprophytic bacteria, while the race-water would contain more sewage organisms. This is admirably demonstrated by the above examinations. Yet, were we to depend on the bacterial count on gelatin alone, the reservoir-water would appear many times worse than the race-water. It is thus seen that by the proper combination of laboratory methods a definite and accurate conclusion may be reached, and it is also evident that in the examination of water reliance on any single method will lead to grave errors.

SOME REFINED METHODS IN WATER PURIFICATION.

By William G. Toplis.

Two years ago it was my privilege to bring to the attention of this body some observations on the hygienic purification of water. Since then, several advances in technique have been achieved that serve to give more accurate data with greater economy in time.

Bacteriological investigation directed to water work has, in the main, a different end from that which is sought, ordinarily, when applied to pathological determinations. The latter effort seeks almost wholly to isolate and identify organisms, where with water the principal study is to determine the number of individual organisms in a definite volume of water, regardless of their kind or character. The assumption being that an impure water will favor the development of a greater number of organisms than a water with little contamination, since organic impurities constitute the food supply for bacterial growth. That this is a fact can readily be demonstrated by a comparative count, on equal quantities of sewage and any potable water. Therefore, in this line of investigation the determination of numbers becomes the principal work, and much energy has been directed to perfecting methods and media calculated to develop the greatest numbers of organisms contained in the water under examination. But while this is the principal effort in the sense of having more time devoted to its study, it does not monopolize the whole importance. It is necessary that a frequent search should be made for a certain organism of the commensal

species, not in the water applied to the filter, but in the effluent. The presence or absence of the organisms here, being a certain indicator of the efficiency of the filter.

The organism sought is known as the Bacillus coli communis, invariably found in sewage. This organism has many features in common with the Bacillus typhosa, and it is almost identical with several organisms found naturally in grain. It is desirable to be possessed of a speedy certain means of identifying the colon bacillus. Several plans have been used, based upon its peculiarities. Among its cultural characteristics is this property, when grown in neutral milk, containing enough blue tr. litmus to decidedly color the milk, the blue color becomes red and a firm coagulum occurs in the test-tube, after eighteen to twenty-four hours' cultivation in the incubator. This red color is due to a change in the reaction of the milk, caused by the transition of the sugar of milk to lactic acid through the agency of the colon bacillus. Advantage is taken of this feature. Plates are made of agar-agar, containing in addition to beef bouillon, sugar of milk, and strongly colored with blue litmus. The plates are prepared by fusing a tube of the media, and when cooled to blood heat, 1 c.c. of the filtered water is added, gently but thoroughly shaken together and poured into the plate. After it is set hard it is placed in the incubator and cultivated at 37½° C. for eighteen to twenty-four hours, when any colon bacilli developed will be made manifest by red colonies on the plate with a considerable red area surrounding them.

Another means of the identification of the colon bacillus is found in its property of causing fermentation when cultivated in a fluid medium containing 1 or 2 per cent. of a fermentable carbohydrate, such as grape sugar. The products of fermentation are conserved and subjected to analysis. The operation is facilitated and best carried out in a special device known as the Smith fermentation tube, devised by Theobald Smith.

An experiment conducted under these conditions yields a gaseous product of from 30 to 50 per cent. of the volume of the liquid used. On examination of this gas it is almost uniformly found to contain 1 part CO_2 and 2 parts of an inflammable gas akin to hydrogen. The two features briefly described were formerly the principal reliance for the identification of the colon bacillus, but it has been so frequently demonstrated that other organisms duplicated these phe-

nomena that further light was diligently sought for more positive means of identification of this germ, and a decided advance has been made in a modification of the Smith tube reaction described by Irons and others.

It has been found that when neutral aniline red is added to lactose bouillon medium in the Smith tube and a culture of the colon bacillus added, after twenty-four hours' cultivation at 37½° C., a characteristic color reaction is caused by the growth of the organism. The liquid in the stem of the tube assumes a decidedly canary color with fluorescence, while that portion of the medium remaining in the tube retains its original bright red color. If, then, all of the results appear, namely, the volume of gas, the proper percentages of it, the acidity and the typical yellow-red contrast reaction, then the organism may be considered Bacillus coli communis. This method can be carried out in twenty-four hours, and the colon bacillus identified with reasonable certainty; whereas the same result with isolation in pure culture would take from five to seven days. The culture to carry out this experiment may be selected from one of the red colonies grown on the litmus lactose agar plates previously described.

The science of bacteriology is so new and its application to water filtration on a large scale so recent that it is still largely in the experimental stage, and it is quite natural that questions should be continually presenting themselves for solution in every branch of the work. One such problem is of interest, and it involves my personal experience. It concerns the preservation of the plates from premature destruction by growths of certain liquefying organisms, too frequently found in river water. As previously stated, no pains have been spared in devising media calculated to coax into active growth all, or as many as possible, of the organisms contained in the water under examination. Wide experience has shown that nutrient gelatin medium fills most requirements better than any other, but it falls down in one respect, at least. There is always present a class of germs in river water, called liquefying organisms. During their life process, they excrete a principle known as an enzyme. This substance, in many cases, is exceedingly active, so great at times as to digest and completely liquefy the entire contents of a plate before its time for incubation had expired. It became necessary to prevent the very frequent appearance of the word "lost" in the report, and, after some experimenting, the problem

unwound itself in this fashion: The plates are of gelatin; gelatin is the principle in hides that is acted upon during the process of tanning to make leather. Leather is not acted upon by enzymes, or, at most, but sparingly. Then, why not tan the plate at the point of attack? This was attempted, and a favorable result followed the use of a strong solution of chrome alum, producing a sort of chrome tannage. The procedure was simple and rapid, and consisted in removing the fluid portion from the gelatin with a pipette and replacing it with the chrome alum solution. The effect was instantaneous. The action of the enzyme was arrested, and, in addition, the reduced chromium made a green area around the colony just as far as the tanning process had penetrated, and thus served as a true indicator of the amount of the plate destroyed. At the same time, being transparent, it permitted the counting of any colonies previously developed within its zone of encroachment.

Enzymes seem to be more or less misunderstood; at least there are statements from authoritative sources concerning them that do not agree entirely. For example, on page 650, Sadtler and Trimble's Pharmaceutical and Medical Chemistry, will be found the statement that the activity of all enzymes is destroyed by boiling with water, and not destroyed by antiseptics. From other sources we have been taught that antiseptics do destroy enzymes. The light of recent investigation inclines to the belief that these horizontal statements cannot be wholly sustained.

Drs. Abbott and Gildersleeve, University of Pennsylvania, have definitely shown that proteolytic ferments produced during the growth of such bacteria as Bacillus pyocyaneus, or Bacillus subtilis, etc., are not destroyed by boiling water and are not prevented from exercising their digestive function by antiseptics—at least, by such an antiseptic as carbolic acid. They found that these enzymes resisted the temperature of boiling water when exposed to it from fifteen to thirty minutes, and afterwards attacked and completely digested a medium consisting of

Gelatin	8·	c.c.
Phenol	·25	"
Water	100·	"

and did this with but slightly diminished vigor.

The science of water purification is a many-sided one, and each side has its peculiar difficulties. This seems especially true of the

Philadelphia project, and from an engineering point of view, that which has given the heads of departments in this city the most concern is perhaps turbidity. The wide limitations and the constantly varying amounts of suspended matter carried by, particularly, the Schuylkill River, served to make a very complicated problem. There is no great difficulty in filtering water carrying suspended matter up to 40 parts per million, but above that figure the scrapings become inconveniently frequent, and the effort has been to prepare the water by sedimentation and other means before passing it to the filters.

At times of freshet the Schuylkill River carries every kind of substance from coal dust to microscopic clay particles, the amount running well up into the hundreds of parts per million, and here is where the great problem lay to supply water of uniformly low suspended matter to the filters. Sedimentation alone, such as was possible, was inadequate, and to build for this purpose not economical. But a chain is no stronger than its weakest link. Those freshets were a stubborn fact, and must be met. Yet how? The answer most hopeful was sedimentation with preliminary filtration. Then came the struggle for a proper preliminary filter. Its great office to remove mud and do it regularly, whether the suspended matter be 500 parts or 50 parts per million,—that was a task to stagger the most optimistic. Still they have gone quite a long way on the road toward its realization. At the lower Roxborough filter plant there is in operation a preliminary filter doing very satisfactory work in a practical way, and at the testing station there has been one of the same type at work for a long time, from which experience was gained as to its durability and efficiency; it has given great promise of good and permanency.

It presents some novel features. The walls of the container are of concrete construction, and it is divided into about ten elements; these are controlled separately. That enables the cleaning of each without interfering with the others. The filtering material consists of several sizes of broken slag; the larger at the bottom and the smaller sizes toward the top. On the surface of the slag is placed a layer of sponge clippings 1 foot in thickness. This is compressed to about 6 inches and held down by a lattice of woodwork over all. This sponge or elastic layer, as it is called, really constitutes the strainer, while the slag divides the water into innumerable

small streams before it reaches the sponge layer, because the water is entered at the bottom and passes upward through the various layers. This device filters water at the rate of 45,000,000 gallons per acre per day, of such a quality that it enables the hygienic filters to deliver clean and wholesome water at the rate of 6,000,000 gallons per acre per twenty-four hours—exactly doubling the capacity of these filters. The commonly accepted rate consistent with good work is not over 3,000,000 gallons per acre in twenty-four hours. As a measure of economy the device is well worth its cost. The cleaning of the sponge layer is accomplished by the aid of machinery, and the outfit bears a strong resemblance to a well-equipped laundry establishment.

At each washing there is some loss of sponge material, but it is not serious. The cost of the sponge clippings is about 5 cents per pound.

To the drug-store mind sponges would not seem to be a desirable substance to apply to this purpose, basing an opinion on experience gained with the drug-store sponge in active service, but as the sponges in the filter are constantly submerged, they do not seem to be subject to the same deterioration.

THE TECHNICAL ANALYSIS OF WATER.

By W. E. Ridenour.

The manufacturer of special chemicals requires the analysis of a water to be stated in grains per U. S. gallon and that two analyses of the same water made at the same time shall not vary more than $\frac{1}{10}$ grain on each constituent.

As upon the chemist's report he determines the chemicals to be used and also the quantity per 1,000 gallons or per 1,000 cubic feet.

The different bases and acids found in solution in the water must also be combined according to chemical affinities, as the elements themselves have no meaning in the business mind: *i. e.*, the chlorine, sulphuric anhydride, carbon dioxide, lime, magnesia, soda, etc., must be combined. That is, the elements found in solution must be stated as they exist in combination in the water.

The scheme of water analysis used in the laboratory of the Geo. W. Lord Company is as follows:

Total Solids.—100 c.c. of the filtered sample of water are evaporated to dryness in a platinum dish on a water bath, and the residue dried at 100 c.c. in an air-bath to a constant weight.

Milligrammes of residue multiplied by ·583 equals grains per United States gallon. (U. S. gallon contains 58329·6 grains.) If this residue is taken up in a small quantity of water and tested with phenol-phthalein, it will often give an alkaline reaction when no sodium carbonate is present. This is due to a slight decomposition of the magnesium carbonate into magnesia, while drying in the air-bath.

A sample of Lake Michigan water shows this reaction:

	Grains per U. S. Gallon.
Sodium chloride	·578
Sodium sulphate	·709
Calcium carbonate	4·316
Magnesium carbonate	1·985
Total solids	8·162
Free carbonic acid	7·761

Silica.—The total solid's residue is taken up in dilute hydrochloric acid, evaporated to dryness, and taken up again in dilute hydrochloric acid. The liquid is filtered, the insoluble residue washed, dried, ignited and weighed, which is the silica.

Milligrammes of residue multiplied by ·583 equals grains per United States gallon. Nitric acid should not be used to dissolve the total solid's residue, as in the presence of sodium chloride there is an action upon the platinum dish, due to the formation of free chlorine.

Iron Oxide and Alumina.—200 c.c. of the filtered sample of water are acidified with hydrochloric acid, a few drops of nitric acid added and boiled to remove all carbonic acid. The liquid is allowed to cool, ammonium chloride added and then ammonia to alkaline reaction; allow to stand for ten minutes, then filter. The precipitate washed, dried, ignited and weighed, is the iron oxide and alumina.

Milligrammes of residue multiplied by ·2916 equals grains per United States gallon.

Calcium Oxide.—The filtrate from the iron oxide and alumina is treated with ammonium oxalate, heated and allowed to stand over night. The liquid is then filtered, the precipitate washed and dissolved in warm dilute sulphuric acid, which is then titrated with standard decinormal permanganate of potash solution. The number

of cubic centimetres required multiplied by ·8162 (500 × ·583 × ·0028) equals grains of calcium oxide per United States gallon.

Magnesia.—To the filtrate from the calcium oxalate add ammonia and solution of sodium phosphate, allow to stand over night. The liquid is then filtered, the precipitate washed with ammonia water, dried, ignited and weighed, which is magnesium pyrophosphate.

Milligrammes of residue multiplied by ·2916 equals grains per United States gallon.

The Sulphates.—200 c.c. of the filtered sample of water are acidified with hydrochloric acid and barium chloride added until it ceases to give a precipitate. Allow to stand over night. The liquid is then filtered, the precipitate washed, ignited and weighed, which is barium sulphate.

Milligrammes of residue multiplied by ·2916 equals grains per United States gallon.

Sodium Chloride.—Titrate 100 c.c. of the filtered sample of water with standard silver nitrate solution, using potassium chromate as indicator. The number of cubic centimetres required multiplied by ·68 (1 c.c. $AgNO_3$ equals ·0011674 × 1000 × ·583) equals grains of sodium chloride per United States gallon.

Calcium Carbonate, Magnesium Carbonate and Sodium Carbonate Combined.—Titrate 200 c.c. of the filtered sample of water with standard decinormal sulphuric acid, using methyl orange as indicator. The number of cubic centimetres required multiplied by 1·4575 (500 × ·583 × ·005) equals combined calcium carbonate, magnesium carbonate and sodium carbonate expressed in grains of calcium carbonate per United States gallon.

Free Carbonic Acid.—100 c.c. of the sample of water are taken, to which is added 3 c.c. of a solution of barium chloride, 2 c.c. of a saturated solution of ammonium chloride, and 95 c.c. of lime-water, the strength of which has been previously ascertained. This is allowed to stand over night in a flask, the 100 c.c. is filtered, titrated with decinormal hydrochloric acid. The number of cubic centimetres so found must be deducted from the quantity required for the lime-water. The remainder multiplied by 2·565 (2000 × ·583 × ·0022) equals grains of free carbonic acid per United States gallon.

The Combination of the Acids and Bases.—Different chemists have different schemes of uniting the bases and acids, which should not be. The most rational method would be to state the acids and

bases separately, but this method would not be accepted by the manufacturer.

The statement of results of an analysis of the same water as interpreted by different chemists is often so different that it reflects distrust upon the profession. When if the analyses were resolved into their acids and bases, they would be found to agree.

Fresenius states that "a certain latitude is here allowed to the analyst's discretion."

As a general rule I state the magnesium as magnesium carbonate as far as possible, this combination has been proven to exist in preference to magnesium sulphate by the following series of experiments:

Two waters were mixed in the proportion of 10 parts of artesian and spring water to 1 part of city water and passed through a heater and a purifier. Samples were collected and examined at the different stages and also a sample of sediment from the purifier.

	City Water.	Springs and Artesian Wells.	After going through heater.	After going through purifier.
Organic and volatile undetermined	2·734	3·797	3·557	1·160
NaCl	6·12	1·836	·782	·952
Na_2SO_4	—	2·032	—	—
$CaCO_3$	1·398	1·355	·795	·649
$CaSO_4$	3·403	7·068	3·233	3·573
$Mg.CO_3$	1·764	1·985	1·544	·662
Solids	9·911	18·073	9·911	6·996
Free Co_2	9·055	4·139	5·174	2·587
$CaCo_3$ by titration	3·498	3·718	2·633	1·521

Grains per United States gallon.

SEDIMENT FROM PURIFIER.

	Per Cent.
Organic and volatile (undetermined)	15·1
$CaCO_3$	12·6
$CaSO_4$	1·7
MgO	15·5
Fe_2O_3	19·6
Al_2O_3	4·6
Oil	3·0
Silt	27·9

If the magnesium existed as a sulphate in the water the deposit of magnesia could not have formed in the purifier, as magnesium sulphate is a stable compound under the influence of heat.

The remainder of the calcium carbonate determined by titration is stated as calcium carbonate and deducted from the amount of calcium oxide found. The remainder of the calcium oxide is stated as calcium sulphate, and deducted from the barium sulphate found, and if any barium sulphate remains, it is stated as sodium sulphate. Each water requires individual study, and if a sample of sediment formed by the water is also examined, it will decide how a certain base and acid exist in the water.

HERBERT SPENCER AND THE METRIC SYSTEM.

By Florence Yaple.

The question of the adoption and use of the metric system of weights and measures in the United States being the subject of so much debate at the present time, it seems fitting that the position of the late Herbert Spencer with regard to this system should be made more generally known, more especially as his opposition to the general adoption of this system was a life-long one, and also because he may be said to have occupied a position such as enabled him to correlate the views of men of science and men of business.

Without considering the origin and history of the metric system, it may be said that in view of the strong national prejudices, which exist in many countries, as well as other impeding influences, it has made comparatively rapid progress, particularly for scientific purposes. The question arises, is this wholly due to the intrinsic merits of the metric system itself, or is it due in part to the need for a system of weights and measures which is international or universal in its application, as indeed the metric system was intended to be? Or, going a little further, may not a better system than the metric system be found, and may not the universal adoption of the metric system prevent finally the adoption of this better system? This was the question which concerned Spencer. He frankly admitted the advantages of a decimal system to the man of science, but thought it was "ill adapted for industrial and trading purposes."

While perhaps it may seem like taking a step backward to give even so much sanction to Spencer's views as to publish them, still

the question remains whether a better system than the metric system could have been devised, and whether we are justified in abandoning our entire system of weights and measures in favor of a decimal system. The time has probably gone by for the introduction of a better system, in view of the general use of the metric system for scientific purposes (if such were possible), but inasmuch as our old system of weights and measures is still adhered to by the vast majority of trades people, a full and free discussion of the subject is desirable.

In view of the efforts being made in England to obtain governmental sanction of the use of the metric system, and being strongly opposed to its adoption, Herbert Spencer, in 1896, communicated four letters to *The Times* (London) setting forth his objections to the system. These letters were immediately afterward embodied in a pamphlet and distributed to all of the members of the House of Commons, a few of the members of the House of Lords, and also to the members of our own Congress. They have since been made more accessible as well as more permanent by being incorporated in Spencer's book, entitled "Various Fragments."

After taking up the derivation of the metric system, Spencer then goes on "to show that its fundamental principle is essentially imperfect and that its faults are great and incurable."

One of the first of the arguments used against the decimal system by Spencer is the fact that although its adoption in France "has been in the main compulsory," there is evidence to show "that the old customs have survived where survival was possible." Not only so, but in the United States, one of the countries of its partial adoption, and on the English Stock Exchange as well, the decimal divisions of the dollar are ignored, "and the division into parts by halving, re-halving, and again halving is adopted."

Arguments are then taken up to show how the order of nature has established certain measures and divisions for us; such as, for instance, the division of the circle into 360 degrees, this being "the outcome of the Chaldean division of the heavens to fit their calendar;" of the year into twelve months, and also into four seasons or quarters, for astronomical reasons; of the compass into thirty-two points, depending upon the "natural relations of the cardinal points."

The practical need for divisions of quarters and thirds in every-day life is also discussed and their inconsistency with a decimal system pointed out.

Having shown that a "mixed system would in large part remain," and that it is impossible to avoid certain incongruities which necessarily result from the use of a decimal system, the author proceeds as follows: "We agree in condemning the existing arrangements under which our scheme of numeration and our modes of calculation based on it, proceed in one way, while our various measures of length, area, capacity, weight, value, proceed in other ways. Doubtless, the two methods of procedure should be unified; but how? You assume that, as a matter of course, the measure system should be made to agree with the numeration system; but it may be contended that, conversely, the numeration system should be made to agree with the measure system—with the dominant measure system, I mean." This "dominant measure system" is, according to Spencer, the duodecimal system. It is shown that it is quite as easy to form a numerical system based upon twelve as it was originally to build up a system having ten as a basis. It is claimed also that "It needs only a small alteration in our method of numbering to make calculation by groups of twelve exactly similar to calculation by groups of ten; yielding just the same facilities as those now supposed to belong only to decimals." But perhaps the strongest of the claims for a duodecimal system is the need for easy division into aliquot parts, twelve being divisible into halves, quarters, thirds and sixths, while the divisibility of ten is of the smallest. That such a claim is not without foundation is evident if we look into the history of weights and measures. While "numeration by tens and multiples of tens has prevailed among civilized races from early times," they have departed from this system in their tables of weights, measures and values, the tendency being toward "systems of easily divisible quantities."

That Spencer was cognizant of the peculiar merits and aims of the metric system cannot be denied, nor, on the other hand, was he unmindful of the difficulties which would attend the introduction of a new system of numeration and measure like that of the duodecimal.

He objected to the metric system "on the ground that it is inconvenient for various purposes of daily life, and that the conveniences it achieves may be achieved without entailing any inconveniences."

Lest Spencer's position should not be rightly interpreted from this necessarily condensed treatment of his article, the following is quoted in extenuation:

"Evidently moved by the desire for human welfare at large, scientific men have been of late years urging that the metric system should be made universal, in the belief that immense advantages, like those which they themselves find, will be found by all who are engaged in trade. Here comes in the error. They have identified two quite different requirements. For what purpose does the man of science use the metric system? For processes of measurement. For what purpose is the trader to use it? For processes of measurement, *plus* processes of exchange. This additional element alters the problem essentially. It matters not to a chemist whether the volumes he specifies in cubic centimetres, or the weights he gives in grammes are, or are not, easily divisible with exactness. Whether the quanties of liquids or gases which the physicist states in litres can or can not be readily divided into aliquot parts is indifferent. And to the morphologist or microscopist, who writes down dimensions in subdivisions of the metre, the easy divisibility of the lengths he states, is utterly irrelevant. But it is far otherwise with the man who all day long has to portion out commodities to customers and receive money in return. To satisfy the various wants of those multitudes whose purchases are in small quantities, he needs measures that fall into easy divisions, and coinage which facilitates calculation and the giving of change. Force him to do his business in tenths, and he will inevitably be impeded."

Finally, it may be said that Spencer was well aware of the advantage to be derived from the application of the decimal method of calculation to quantities and values; that he was in favor of a uniform system of weights and measures, but held that this was not possible with the metric system, believing that it would necessarily be traversed by other systems, and, notwithstanding the difficulties which would oppose the introduction of a duodecimal system, he believed that its merits were such as to warrant the use of our present mixed system until such time as this more perfect system could be adopted.

PROGRESS IN PHARMACY.

A QUARTERLY REVIEW OF SOME OF THE RECENT LITERATURE RELATING TO PHARMACY AND MATERIA MEDICA.

By M. I. Wilbert, Ph.M.,
Apothecary at the German Hospital, Philadelphia.

The necessity of a higher, or a more thorough technical education for the coming generations of pharmacists, is being actively discussed in several European countries, particularly in Germany and in England. In these countries it is generally conceded that if apothecaries or pharmacists are to retain any professional standing, their education must be in keeping with the advances that have been made in the several departments of science more or less closely related to their occupation or profession.

The general trend of this discussion, in England, is well illustrated by several papers recently published in the *Pharmaceutical Journal* (1904, pages 78 and 82).

"University Education for Pharmacists" is the title of the paper contributed by Prof. Robert B. Wild, of Victoria University, Manchester. In this paper the writer recognizes the necessity of a further and, ultimately, a complete, separation of the trade or commercial branches from the professional or scientific portion of the pharmacist's occupation.

One of the reasons for the present depressed condition of pharmacy Mr. Wild finds in the fact that pharmacists, as a class, have not maintained the intellectual superiority over the general public, possessed by them a generation ago. He believes that pharmacists must adapt themselves to the advancing scientific requirements of the present and the future, and unless they are willing to allow the legitimate development of the scientific portion of their profession to be taken up by others, they must appreciate and provide the equivalent of a university training for the pharmacist of the future.

This paper by Professor Wild contains many suggestions that are applicable to the conditions existing at the present time in our own country. Here, as in England, we have come to the parting of the ways, and in the very near future there will be a need for, and also a due appreciation of, the scientifically inclined and properly educated pharmacist who is willing and able to occupy relatively the same

position to the medical profession and to the general public as did the pharmacist of a generation or more ago.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES IN AMERICAN PHARMACY.—An open letter, headed "Alternative Formulas," published on page 88 (February, 1904) of the AMERICAN JOURNAL OF PHARMACY, may possibly represent the ideas of a number of so-called pharmacists, but it certainly cannot represent the opinions of any one that has tried to keep in touch with the progress in chemistry and other sciences allied to pharmacy. In this connection it would be preposterous, indeed, to assert that the average American pharmacist is not as progressive, or as capable of progressing, as is his fellow craftsman of Germany, Italy or even Russia.

The writer of the letter noted above makes one uncontrovertible statement when he says that "the Pharmacopœia must be a book of working formulas, and these as plain, simple and direct as science in her modesty can make them."

If we compare the formulas of the United States Pharmacopœia with those published in the Dispensatories, or even with the formulas for corresponding preparations in the British Pharmacopœia, it will not be dificult to decide as to which of the three should be designated as being plain, simple and direct.

There is, however, much more to be said in favor of retaining the metric system alone in the coming United States Pharmacopœia. The Pharmacopœia is, or should be, intended for pharmacists, and not for drug-sellers or patent-medicine vendors.

To be a pharmacist, one must be conversant with the chemical tests that are available for the quantitative as well as qualitative examination of drugs, chemicals and preparations.

Any one that has ever attempted quantitative chemical analysis, particularly when volumetric processes are involved, will appreciate the advantages of a decimal system of weights and measures.

So far as known, the metric system of weights and measures is the only decimal system available or in use, and this system, in addition, has the advantage of being universally used by chemists and scientific investigators generally.

If these assertions are based on facts, the Pharmacopœial Revision Committee would be making a very serious mistake to deviate, in any way, from the now well-established practice of having a very high-class book, intended only for such as are willing or anxious to do high-class work.

How the better class of English pharmacists feel about the coming revision of their national standard, is evidenced by a paper on "The British Pharmacopœia," by J. W. Turner (*Phar. Jour.*, 1904, page 96). This writer not only recommends that the General Medical Council adopt the metric system only, in the formulas of the Pharmacopœia, but also that the doses be given in metric quantities alone.

THE BUREAU OF STANDARDS of the Department of Commerce and Labor, under date of December 15, 1903, has issued a circular in reference to the *testing of clinical thermometers*, that will no doubt be of interest to such pharmacists as sell or handle these very essential requisites for the sick-room.

The series of tests that have been devised by this bureau will insure satisfactory instruments under all conditions, as no thermometer that is defective or that exceeds the allowable limits of error will be given a certificate by the Bureau. The proposed charges are quite reasonable, and are according to quantity:

(1) In lots up to 8, each	$ 25
(2) Any number between 8 and 12, total fee	2 00
(3) In lots of 1 dozen or over and less than 4½ dozen, per dozen	2 00
(4) Any number between 4½ and 6 dozen, total fee	9 00
(5) In lots of 6 dozen or over, per dozen	1 50

In this connection it may be of interest to give some extracts from a circular letter issued by the bureau, under date of December 1, 1903:

"The functions of the Bureau of Standards are as follows: The custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce and educational institutions, with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials. The Bureau will also furnish such information concerning standards, methods of measurements, physical constants, and the properties of materials as may be at its disposal, and is authorized to exercise its functions for the Government of the United States, for State or municipal governments

within the United States, for scientific societies, educational institutions, firms, corporations or individuals engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments.

"For all examinations, calibrations, tests or investigations, except those performed for the Government of the United States or State governments, reasonable fees will be charged."

The Bureau at the present time occupies temporary quarters in the city of Washington. Permanent laboratories are in process of construction, and when completed the Bureau will be enabled to do even more extensive work than is undertaken at the present time. The present schedule of testing includes measures of length, weights, measures of capacity, polariscopic apparatus, hydrometers, thermometers, photometric standards, and a variety of determinations as to the accuracy of electrical instruments.

The Bureau is desirous to co-operate with those interested and to supply them with such information on the subject of weights and measures as may be in its possession.

All communications should be addressed, "Bureau of Standards, Department of Commerce and Labor, Washington, D. C."

PHARMACY IN CHICAGO.—Under the title "Reminiscences of Early Chicago and its Druggists," Mr. Albert E. Ebert is now publishing a very interesting and readable series of articles in the *Western Druggist*, Chicago.

The first instalment of this very valuable contribution to the history of American pharmacy appeared in the December, 1903, number of the *Western Druggist*, and includes, among other interesting material, an outline sketch of the founding of Chicago, and also some reference to the first settlers.

ATOMIC WEIGHTS.—The International Committee on Atomic Weights reports but two, unimportant, changes in the list of atomic weights. Caesium is given as 132·9, to accord with the determinations made by Richards and Archibald, while cerium, according to the measurements by Brauner, is said to have an atomic weight of 140·25. Both of these are the weights as compared to oxygen = 16. A number of the other elements are known to be more or less uncertain as to the accuracy of their atomic weights, but it was not considered advisable to make any radical changes while work was still under way. (*Jour. Am. Chem. Soc.*, 1904, page 1.)

BOTTLES, FROM WHAT ARE THEY FASHIONED? is the title of a paper recently contributed by Mr. E. O. Rowland to the Edinburgh Chemists' Assistants and Apprentices Association. The writer of the paper, after giving an interesting historical account of the origin and development of glass manufacture, gave a detailed account of the various materials and processes employed in the making of glass. The composition of the several kinds of bottle glass was given as follows:

White glass for ordinary moulded bottles, sand, 64; lime, 6; carbonate of sodium, 23; nitrate of sodium, 5.

White flint glass containing lead, sand, 63; lime, 5; carbonate of sodium, 21; nitrate of sodium, 3; red lead, 8.

Ordinary green glass, sand, 63; carbonate of sodium, 26; lime, 11.

Sand, lime and sodium carbonate are the ordinary bases of glass, the sodium nitrate is added as a decolorizing agent or wash.

The blue tint of poison bottles is obtained by the addition of black oxide of cobalt to the molten glass. The green tint of actinic glass is obtained in the same way by adding potassium bichromate, while the amber tint is usually obtained by the addition of manganese dioxide. (*Phar. Jour.*, 1904, page 96.)

ACHROIN.—This is said to be an aromatic liquid having a specific gravity of 1·055, and a boiling point of 218° C.

It is to be given in capsules of 0·25, as an antiseptic in affections of the urinary tract. (*Süd. Deut. Apoth. Zeit.*, 1903, page 904.)

ADULTERATED SPIKE OIL.—E. J. Parry and C. J. Bennett (*Chem. and Drug.*, 1903, page 1011) report that large quantities of adulterated oil of spike are found on the English market. The specific gravity, optical rotation and solubility are within the limits given by most authorities, but careful examination will usually reveal the presence of one or more foreign bodies.

The usual adulterants are oil of turpentine, oil of rosemary and safrol.

ADULTERATED CITRONELLA OIL.—Parry and Bennett (*Chem. and Drug.*, 1903, page 1061) found 20 per cent. of alcohol in a shipment of citronella oil recently imported into England.

This adulterant, the writers think, is a particularly dangerous one when the oil is bought or sold by Schimmel's test.

Schimmel's test for citronella oil: The oil should give a clear solution with 1 or 2 volumes of 80 per cent. alcohol at 20° C., and

should remain clear even when 10 volumes of alcohol of the same strength are added.

DETERMINATION OF THE ADULTERANT IN CITRONELLA OIL.—M. K. Bamber suggests that a mixture of 2 c.c. of pure cocoanut oil, free from acid, and 2 c.c. of oil of citronella be shaken for one minute with 20 c.c. of 83 per cent. alcohol, in a graduated tube. This container is then centrifugated for one-half to one minute. The volume of the remaining undissolved oil, minus 2, the amount of cocoanut oil used, indicates the impurity. To eliminate any possibility of error, a standard oil may be compared with the suspected sample. (*Phar. Jour.*, 1904, page 28, from *Proc. of Chem. Soc.*)

AUSTRIAN TURPENTINE.—Tschirch and Schmidt (*Arch. d. Phar.*, 1903, page 583), report finding 25 per cent. of laricopinic acid. This is an amorphous acid having the formula $C_{22}H_{30}O_8$; 34 per cent. of laricopinonic acid, a crystalline substance having the formula $C_{20}H_{28}O_4$; 35 per cent. of essential oil having specific gravity of 0·872 and boiling between 154 and 164° C.; 2 per cent. of indifferent resene and 3 or 4 per cent. of impurities which were not determined.

BISMUTOSE.—This is a colloid bismuth albuminate, having a yellow color, and said to contain 21.7 per cent. of metallic bismuth, about 3·3 per cent. of chlorine and 68 per cent. of albumin, the remainder being water. It is made, under a German patent granted to Kalle & Co., by dissolving 242 grams of crystallized bismuth nitrate in 1·200 c.c. of a concentrated solution of common salt, and then filtering the solution into a solution of 500 grams of pure egg albumen in 5 liters of water. The resulting gelatinous mass is then washed with hot water until free from acid and salt; it is then pressed, dried and reduced to a powder. The dose is from 1·0 to 5·00. (*Chem. and Drug.*, 1904, page 106,)

BISMUTH OXYIODO-AGARICINATE.—This bright grey, amorphous, insoluble powder is an iodo compound of bismuth and agaricinic acid. Like dermatol, it is intended to be used as an astringent antiseptic. It is also recommended as a remedy in the treatment of the gastric and intestinal complaints that complicate tuberculosis. (*Phar. Jour.*, 1903, page 924, from *Phar. Zeit.*)

EUMYDRIN-ATROPINE METHYL NITRATE is produced by the conversion of the tertiary base of atropine into a quaternary base. Eumydrin is a white, odorless, water-soluble powder that may be

used as a mydriatic in place of atropine. In action it is said to be intermediate between homatropin and atropine. (*Phar. Post*, 1903, page 780.)

EXODIN.—This is the trade name for a new aperient that is being marketed in Germany. It is said to be an Oxy-anthra quinone derivative. It is a yellow powder, insoluble in water and only slightly soluble in alcohol. The adult dose of exodin is from 1·00 to 1·50 gm. (*Apothek. Zeit.*, 1904, page 16.)

IBOGA.—A Congo plant bearing this name has been examined by Landrin and Dybowsky. Iboga is said to possess properties similar to both coca and kola. Its physiological properties are due to an alkaloid, named by the investigators, ibogaine. Ibogaine in a pure state is insoluble in water, but soluble in alcohol, ether, chloroform and benzene. Ibogaine causes local anæsthesia like cocaine, while in its action on the medulla oblongata it resembles kola. (*Phar. Jour.*, 1904, page 107, from *Schweiz. Woch.*)

IODTERPIN.—If equal parts of iodine and terpin hydrate are finely powdered, mixed, and then gently heated on a water bath, they readily unite to form a new compound, called by Mas and Grindel iodterpin. Iodterpin is a thick viscid liquid, having a specific gravity of 1·19 at 15° C., and boiling between 165 and 175° C. It is readily soluble in ether, chloroform, benzine and benzol, and has a characteristic odor, somewhat resembling terpin hydrate.

Iodterpin may be used in place of iodine, and has also been suggested as a substitute for iodoform. (*Apothek. Zeit.*, 1904, page 14.)

MUSK, ARTIFICIAL.—The price of this in Germany has dropped from 1900 marks to 125 marks a kilo. This decline is due to the fact that the German patents have expired. The *Pharmaceutische Centralhalle*, in commenting on this marked difference in price, expresses the hope that the now comparatively low price will not be sufficient inducement for the too liberal use of this particular perfume.

Artificial musk should not be confounded with the natural product, as, despite the somewhat striking musk-like odor, it is quite different in composition and in its physiological action. Chemically, it is said to be a trinitrobutyl derivative of toluol, xylene or an allied substance. One of the commercial brands that is said to have an especially fine odor, closely resembling that of musk, is said to be trinitro-iso-butyl-xylene.

PHARMACOTHERAPY OF THE ESSENTIAL OILS.—This is the subject-matter of a lengthy essay in the latest *Semi-annual Report of Schimmel & Co.* Much of the original work contained in this essay was done under the personal supervision of the well-known pharmacologist, Professor R. Kobert, of Rostock. The essay is particularly interesting from the fact that the various oils have been arranged in groups or classes according to their physiological action or possible uses in medicine. Thus, the different essential oils are enumerated as odor corrigents, odorous taste corrigents, stomachics, uterine remedies, diuretics, diaphoretics, antihydrotics, antiseptics, leukotactics, antiparasitics, antidotes, dermerethistics, excitants, sedatives and expectorants.

It will readily be seen, from this list, that essential oils may, and do, have a very wide field of usefulness in medical as well as in pharmaceutical practices, and that it is quite probable that further investigations along these lines may even enlarge on the uses of these very interesting and valuable remedial agents.

PONTICIN is the name given by Gilson to a new glucoside which he has extracted from two species of rhubarb—*Rheum rhaponticum* and *Rheum undulatum*.

Ponticin occurs as white crystals that gradually become yellow or even rose colored; are insoluble in water, alcohol and most other solvents, but soluble in a mixture of warm acetone and water. On hydrolysis it yields dextrose and a new body which the author terms pontegenin. Ponticin melts at 231° C. and pontegenin at 187° C. (*Chem. and Drug.*, 1904, page 15, from *Rept. de Phar.*)

RHEIN FROM ALOE EMODIN.—O. A. Oesterle (*Schweiz. Woch. f. Chem. u. Phar.*, 1903, page 599) reports that he has been able to oxydize a portion of an acetic acid solution of aloe emodin into rhein by means of chromic acid. From the analytical data furnished the product appears to be identical with the rhein obtained from rhubarb.

RHOMNOL.—This is the name given by a French firm to a nucleinic acid obtained from the thymus gland of calves. (*Phar. Centralh.*, 1904, page 6.)

SALIBROMIN is a white unctuous powder, insoluble in water and acids, but soluble in alkalies. It contains 44·5 per cent. of salicylic acid and 51·6 per cent. of combined bromine. It is given in doses of 0·50 to 1·50 as an antirheumatic. (*Phar. Centralh.*, 1903, page 480.)

SOLUBLE ADRENALIN POWDER.—Mansier (*Schweiz. Woch. f. Chem. u. Phar.*, 1904, page 46), gives the following formula for a compound powder of adrenalin that he claims to be readily soluble in water: Adrenalin, 0·05; citric acid, 0·10; boric acid, 4·85; mix. One centigramme of this powder corresponds to 10 drops of a 1/1000 solution.

SUBCUTINE is the name given to the paraphenol sulphonate of anæsthesine, or the paraphenol sulphonate of para amido benzoic ethyl ester. Subcutine occurs in small white needles, melting at 195·6° C., and is soluble in 100 times its weight of water. Subcutine is not decomposed by boiling, so that solutions of it may be sterilized. It is said to be a powerful local anæsthetic and quite devoid of any toxic action. (*Phar. Jour.*, 1904, page 99, from *Muench. Med. Wochenschr.*)

SYNTHESIS OF NICOTINE.—Pictet and Rotschy have succeeded in producing nicotine synthetically. This has been accomplished by treating nicotyrine in alkaline solution with iodine, thus producing a monoiodnicotyrine; by treating this with tin and hydrochloric acid they are able to produce a dihydronicotyrine, which, when treated with bromine, is converted into a perbromide. The perbromide is then reduced with tin and hydrochloric acid, and is converted into inactive nicotine.

For splitting this inactive nicotine into its optically active components, tartaric acid is used. The physical properties of synthetic nicotine are said to be identical with those of the natural. (*Phar. Centralh.*, 1903, page 756.)

TRIGEMIN is produced by the action of butyl chloral hydrate on pyramidon. It occurs as white needle-like crystals readily soluble in water. Trigemin when given in doses of from 0·50 to 1·20, is said to be particularly effective as a remedy in migraine and facial neuralgia. (*Phar. Centralh.*, 1903, page 680.)

PARAGANGLIN is one of a number of trade names for the active constituent of suprarenal glands. (*Phar. Post*, 1903, page 781.)

YEAST EXTRACT SUBSTITUTES FOR MEAT EXTRACTS appear to have found their way into the English market. A. Searl (*Phar. Jour.*, 1903) gives the following ready means of detecting yeast extracts:

Prepare a modified Fehling's solution by dissolving 12·0 gm. of cupric sulphate and 15·0 gm. of neutral sodium tartrate in 120·0 gm. of water; add to this 15·0 gm. of sodium hydrate that has

been dissolved in 150·0 gm. of water. Then dissolve 0·60 gm. of the suspected extract in 45 c.c. of water, add one-half of the alkaline cupric sulphate solution and boil for one or two minutes; genuine meat extract does not produce any precipitation, while yeast extract produces a copious bluish white curdy precipitate.

NEW PROCESS FOR ZINC OXIDE.—The *Chemist and Druggist* (1904, page 40) credits Sir William Ramsay with devising a process for making zinc oxide direct from ore or tailings by dissolving the zinc in the ores in sulphuric acid, precipitating with ammonia and subjecting the resulting hydrate to intense heat in a muffled furnace.

A SYMPOSIUM ON THE MEANING OF THE TERMS, PHARMACOLOGY, PHARMACOGNOSY, MATERIA MEDICA AND RELATED TERMS.

Owing to the recent developments in the study of pharmacology, and also owing to the confusion which seems to exist in the minds of a good many people in regard to the meaning of this and other terms, applied in the study of drugs and medicines, it occurred to the editor of this JOURNAL that it would be interesting and profitable to have these terms defined according to their modern acceptation and uses; and with this end in view letters have been sent to a number of physicians and professors in these branches, in various parts of the country. The replies follow in the order of the dates on which they were written or received:

Dear Professor Kraemer:

The use of pharmacological terms by writers has been so various and often so absurd that custom may be said to favor anything except unity of employment of terms of this character. The following scheme seems to me as near the original meaning of the terms as can be at this time guessed, and to be the proper use of them from the scientific point of view.

Pharmacology.—The science which treats of drugs in all their properties and possible relations; and includes as subordinate terms *Materia Medica, Pharmacy* and *Therapeutics.*

MATERIA MEDICA.—The science which treats of the natural and commercial history of drugs, their physical properties and their chemistry.

PHARMACY.—The art which has for its province the preparation of drugs for practical use in medicine.

THERAPEUTICS.—The science and art whose province is the use of medicines for the relief of disease.

Materia Medica has never been divided, so far as I know, into component parts in terminology, but has for a subordinate term, *Pharmacognosy*, which is the science and art of the recognition of drugs.

Therapeutics is divided—

(1) *Pharmacodynamics*, the science which treats of the action of drugs upon living forms, especially upon the animal creation. It is equivalent to the term, *Physiological action of drugs*.

(2) *Practical Therapeutics*, the art of applying the knowledge acquired in Pharmacodynamics to the relief of disease.

HORATIO C. WOOD.

PHILADELPHIA, January 15, 1904.

Dear Sir:

In reply to your letter of inquiry let me state that I use the word "Pharmacology" to describe what might be called the Laboratory or Experimental Method of Studying the Action of Drugs. I apply the term "Materia Medica" to the list of medicinal materials which are employed for the relief or cure of disease, and the term "Pharmacognosy" to the study of the individual constituents of the Materia Medica, pharmaceutically, botanically and chemically.

Very truly yours, H. A. HARE.

PHILADELPHIA, January 15, 1904.

My dear Dr. Kraemer:

Your desire to bring about a sharper definition of the terms relating to the branches of science dealing with drugs, is most laudable. Its necessity is shown, for instance, by the fact that Webster's Dictionary gives as one of the definitions of pharmacology: The art of preparing medicines. This meaning of the word is now so obsolete that its retention can only lead to ridiculous mistakes. The Century Dictionary gives a much more acceptable definition; but it fails to differentiate between pharmacology, pharmacognosy and materia medica. The etymology of these words, indeed, does not furnish any basis for their differentiation. The development of the

science, however, has made specialization necessary; and the older generic names have been applied to these specialties. This specialization did not always occur along the same lines of cleavage; and the use of the terms has accordingly been rather loose. This confusion was enhanced by the original similarity of meaning, which made it optional to use one term or the other for any of the very different specialties. At present, however, the use of these terms has become fairly definite, at least with specialists, although not with the general public. The time seems at hand when a common agreement to their definitions could and should be reached.

The entire branch of science dealing with drugs may be called pharmacology, materia medica or pharmacognosy. To avoid confusion with the restricted meaning of these words, the adjective "general" may be prefixed. Either pharmacology or materia medica may be preferred, according to which of these subjects, in their restricted sense, is emphasized. Pharmacognosy, in this sense, appears superfluous, and should be abandoned.

The specialization has occurred along the lines of the special objects and methods of the study of the science, and may be divided into four groups, which, together with the terms commonly applied to them, are briefly as follows:

(1) The action of drugs on living structures: *Pharmacology.*

(2) The physical and chemical characters of drugs: *Materia Medica.*

(3) The preparation of drugs for medicinal use: *Pharmacy.*

(4) The application of remedies to the treatment of disease: *Therapeutics.*

These divisions and their further sub-divisions can be conveniently presented, as in the following table:

Pharmacology (General). Synonyms: Materia Medica. (Pharmacognosy).	*Materia Medica.* Synonyms: Pharmacognosy, Pharmacographia: The physical and chemical characters of drugs and their preparations; their constitution, structure, history, derivation, dosage, etc.	Comprises: Crude Organic Drugs. Organic Chemic Principles. Inorganic Chemic Principles. Pharmaceutic Products.	Constitutes: *Organic Materia Medica* (synonym Pharmacognosy). Includes: Gross Anatomy. Histology. Chemic Character.
	Pharmacy: The preption of drugs.		
	Pharmacology (Physiologic). Synonym: Pharmacodynamics. Reaction between drugs and living structures.		
	Therapeutics: The medicinal application of remedial agents.		

This would lead to the following definitions:

I. PHARMACOLOGY: (1) Wider sense (also *General Pharmacology*): *All that scientific knowledge pertaining to drugs.* This term should be preferred to its synonym, materia medica, if the emphasis is put on the action of drugs.

(2) Restricted sense (also *Physiologic Pharmacology*), or *Pharmacodynamics*): *All scientific knowledge pertaining to the reactions between drugs and living structures.* (The science so defined will utilize materia medica and therapeutics, as it does physiology, physics and chemistry; but does not include them.)

II. PHARMACODYNAMICS: A little-used synonym of physiologic pharmacology.

III. MATERIA MEDICA: (1) Wider sense: Synonymous with general pharmacology; being preferred when the emphasis is on the physical and chemical characters of the drugs.

(2) Restricted sense: *All scientific knowledge pertaining to the physical and chemical characters of drugs, their source, preparation and dosage.*

This includes their designation, source, habitat, collection, etc.; gross and microscopic structure; chemical constitution and characters; physical properties (appearance, odor, taste, solubility, specific gravity, etc.); and dosage.

The subject may be sub-divided into the materia medica of crude organic drugs; of organic and inorganic principles; and of pharmaceutic products.

Organic Materia Medica (also *Pharmacognosy*) *treats of the materia medica of crude organic drugs.* It is often convenient to subdivide it into their gross anatomy, histology and chemic properties.

IV. PHARMACOGRAPHIA: A practically obsolete synonym of Materia Medica.

V. PHARMACOGNOSY: (1) In the wider sense, an objectionable synonym of General Materia Medica.

(2) Restricted sense: Synonymous with Organic Materia Medica.

(3) Often further restricted to *the science of identifying drugs.*

VI. PHARMACY: *The science and art of preparing drugs for medicinal use.*

VII. THERAPEUTICS: *The application of drugs and other remedial agents* (such as electricity, etc.) *to the treatment of disease.*

Very sincerely yours, TORALD SOLLMANN.

CLEVELAND, O., January 20, 1904.

Dear Professor Kraemer:

I agree with you thoroughly that there is a decided haziness surrounding the term "pharmacology," although perhaps not as much around the other two words mentioned. I will not refer to any dictionary, but give you my definition or conception of the three terms:

Pharmacology is the science which treats of the physiological effects of drugs upon the several parts of the living organism.

Materia Medica is that branch of medicine which describes drugs, their therapeutic effects and doses.

Pharmacognosy is the science which treats of the history, derivation, physical properties, adulterations and chemical constituents of drugs, and methods of recognizing the same.

Therapeutics is the art of applying drugs in disease.

Very truly yours, A. R. L. DOHME.

BALTIMORE, MD., January 21, 1904.

My dear Dr. Kraemer:

I am fully aware of the uncertain and confused use of the terms materia medica, pharmacology, pharmacognosy, pharmacography and pharmacodynamics. Custom is just as apt to fix a term as is correct etymology. It is furthermore true that as we advance in the knowledge of a subject we cannot appropriately retain and apply the terms of the past. Without, however, entering into lengthy explanations and discussions I would offer the following:

Materia medica (there is no plausible reason why we should continue to follow the old custom of beginning these two words with capitals), which means medicinal things or substances or agents, from the standpoint of the pharmacist should be applied to that course in the curriculum of pharmaceutical studies treating of substances (animal, vegetable, mineral, imponderables as light, air, electricity, etc.) used in the practice of medicine, giving the major attention to physiological action and the doses of the various preparations.

Pharmacology has a broad, extensive meaning and includes pharmacy or the art of preparing medicinal substances as well as their action and uses. The term cannot well be applied to any one course or one department of a college of pharmacy. It could be applied to pharmacy and pharmacography as distinct from chemistry and

botany. Pharmacognosy is in my estimation synonymous with pharmacology, although many teachers use it in a more restricted sense as applying to a description of drugs, animal and vegetable. Organic materia medica is by some teachers given the same application or meaning as pharmacognosy.

Pharmacography, which simply means a description of drugs, is, in my opinion, especially applicable to that course of instruction treating of the morphology (crude or gross morphology and histology), history, origin, habitat, commerce, constituents, collecting, drying, garbling, curing and powdering of crude drugs; cultivation of drug-yielding plants, etc. This course must of necessity be distinct from pharmacy, chemistry, and materia medica. I have applied the term pharmacodynamics to that course which treats of drug action based on laboratory tests or experiments on animals. Colleges of medicine usually designate such a laboratory course as pharmacology, it seems to me erroneously for reasons given above.

The following tabulation will perhaps aid in making clear the relationship and relative importance of the terms referred to in the above. I would suggest discontinuing the use of the term pharmacognosy entirely, because of the indefinite way in which it is applied.

I. Pharmacology.
(1) Pharmacy (including a course in dispensing).
(2) Pharmacography (vegetable and animal).
(3) Materia medica (general).
(4) Pharmacodynamics (principally toxicology).
II. Chemistry (general and pharmaceutical).
III. Botany (general and pharmaceutical).

It is of course understood that vegetable pharmocography is special botany.

In conclusion I would express the hope that the conference of teaching faculties may take this matter up and decide upon a uniform nomenclature to be used by colleges of pharmacy.

Yours very truly, ALBERT SCHNEIDER.

SAN FRANCISCO, CAL., January 25, 1904.

Dr. Henry Kraemer, Editor AMERICAN JOURNAL OF PHARMACY.

Dear Sir: In reply to your letter of the 15th inst., I would say that there is much confusion in the use of the terms mentioned,

due to the application of words in defiance of their derivation, and regardless of their meaning. This is seen in the employment of the synonymous terms *Pharmacology* and *Pharmacognosy* for two different subjects, and in the extension of the term *Materia Medica* to include matters wholly beyond its proper scope. A comprehensive and correct schema would be about as follows:

Pharmacology or **Pharmacognosy,** the science of medicines, divided into:

(1) MATERIA MEDICA, their description, physical properties, chemistry and dosage.

(2) PHARMACODYNAMICS, or PHARMADYNAMICS, their powers and fate in the body, divided into:

(*a*) *Physiological Action*, in small and full doses.

(*b*) *Toxicology*, in lethal doses, including their antidotes and physiological antagonists.

(3) PHARMACY, the art of their preparation for medicinal use,

(4) THERAPEUTICS, their use in disease.

Of course many subdivisions could be made, but the above would form the main schema, would be consistent and readily understood. Under Materia Medica, a subdivision, *Pharmachemics*, would include solubilities and incompatibility. Therapeutics might be divided into *natural*, *empirical* and *rational therapeutics*, so as to make the subject systematic in all its ramifications, but these refinements are outside the limits of your question.

Very truly yours,

SAMUEL O. L. POTTER, M.D. (Jeff.),
M.R.C.P., London.

SAN FRANCISCO, CAL., January 25, 1904.

My dear Kraemer:

The following are excerpts from papers which I have already published:

It would seem unnecessary to define in the columns of a medical journal what is meant by pharmacology, but the frequent confusion of this term with pharmacy by those who are not teachers of medicine must serve as a reason for a brief statement of the methods and aims of this branch of medical science.

The vague and often erroneous use of the word pharmacology seen in earlier writings, as in the definition of Nathan Bailey (1736),

"a treatise concerning drugs," or in that of Samuel Johnson (1755), "an equivalent of pharmacy or pharmaceutics," is still frequently met with in our own time. Briefly stated, pharmacology tries to discover and explain all of the more obvious functional, and the less noticeable chemical and physical changes that occur in a living thing that has absorbed a substance capable of producing such changes, and it is also its province to learn the fate of the substance thus incorporated. It is not, therefore, an applied science like therapeutics; it is one of the biological sciences, using that term in its widest sense.

Now what does this revival of an old word mean? One of the most eminent investigators in this field, Professor Schmiedeberg, of Strassburg, has defined pharmacology as "The study of the changes brought about in living organisms by chemically acting substances (with the exception of foods), whether used for therapeutic purposes or not."[1] It is to be noted that these changes induced in the body are not merely such as can be expressed in the terms of an equation, but include those varied molecular processes which lie in that ever-widening borderland between physics and chemistry, where hide the secrets of vital activity.

Like its sister sciences, physiology, physiological chemistry and pathology, it is making great progress along certain physical and chemical lines, which is pioneer work of a necessary kind toward an explanation of vital processes.

Yours faithfully,

JOHN J. ABEL.

BALTIMORE, MD., February 1, 1904.

[*To be continued.*]

REVIEWS AND BIBLIOGRAPHICAL NOTICES.

ELEMENTARY DISPENSING PRACTICE, FOR STUDENTS OF PHARMACY AND MEDICINE. By Joseph Ince, F.C.S., F.L.S., F.R.M.S., Pharmaceutical Chemist, Associate of King's College, London, late Lecturer in Pharmacy to the Pharmaceutical Society of Great Britain, formerly Member of Council and Examiner. Published at the offices of the *The Chemist and Druggist*, 42 Cannon Street, London E. C., 1903. Price, 3*s.* 6*d.*, net.

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[1] Schmiedeberg, "Grundriss d. Arzneimittellehre." II. Aufl., s. 1.

This book, as suggested by the title, is composed of a very large number of examples intended for the practical instruction of prospective dispensers of medicines. As indicated by the price, the book is not a very large one, and being published in England, and the contained examples being based on the preparations of the British Pharmacopœia, the book is not particularly well adapted for beginners in pharmacy in this country. For more advanced students, however, or for such pharmacists or teachers of pharmacy as are willing or anxious to learn by having thoughts and ideas suggested to them, this little book will be worth many times the moderate price that is asked for it by the publishers.

Mr. Ince, the author of the book, is well known to the English-speaking pharmacists throughout the world, having been a liberal contributor to pharmaceutical journals for more than half a century. During this long period of time Mr. Ince has naturally profited by his experiences, and has acquired a large and evidently well assorted collection of miscellaneous knowledge bearing on pharmacy in all its branches. That he is well fitted to give an exposition of the art of dispensing is evidenced by every page in the book.

It must be remembered, of course, that many of the contained suggestions are not applicable to practice in this country, and also that many of the ideas and opinions are the expressions of a man that has long since passed the time when he was ready or anxious to take up with what might be termed new ideas or new methods. The book consists of about 150 pages, and is divided into twenty-one, generally short, chapters, and a liberal, well-arranged index.

Among the more interesting or more important chapters we may enumerate those on: Precautions in Dispensing, Simple Solutions, Pilulæ, Emulsiones, Linimenta, Ungenta, Suppositoria, Pulveres, Emplastra, and Definitions.

Pills and emulsions are given the greatest amount of attention; the chapter on pills occupying 30 pages, while 22 pages are devoted to the consideration of emulsions. It will be generally admitted that a thorough familiarity with these two classes of preparations should be, quite properly, considered to be of greatest importance to a prospective dispenser.

Altogether it may be said that the number and variety of examples given, with the accompanying directions and explanations, will contribute materially to make a student familiar with, and also teach

him how to avoid, many of the difficulties that arise in everyday practice, while, as noted before, to the pharmacist or the teacher this book should be an almost inexhaustible fund of ideas and suggestions.

The book throughout bears evidence of the originality and individuality of Mr. Ince, and this fact alone should recommend it to all that have seen or become familiar with any of his interesting, and always sprightly, contributions to pharmaceutical literature.

M. I. WILBERT.

PHARMACEUTICAL MEETING.

The fifth of the Pharmaceutical Meetings of the Philadelphia College of Pharmacy of the present series was held on Tuesday, February 16th, at 3 o'clock. Mr. Mahlon N. Kline, chairman of the Board of Trustees, presided. In opening the meeting Mr. Kline remarked that the papers to be presented would be of great interest to Philadelphians, as upwards of $25,000,000 are being spent to secure a pure water supply for this city.

The first speaker on the programme was W. E. Ridenour, a specialist in the chemical analysis of water, who read a paper on the "Technical Analysis of Water." (See page 121.)

In answer to a question by Mr. E. M. Boring, Mr. Ridenour stated that it required about three days to complete an analysis of water, but that usually four analyses were conducted at the same time; and in reply to Prof. C. B. Lowe he stated that while a quart of water was sufficient for analysis, he preferred to have a gallon submitted.

Mr. Ridenour said in addition that the following is the scheme of analysis, used by the chemist of the Northwestern Railroad, for the separation of the scale-forming constituents from the non-scaling matter:

Five hundred cubic centimetres of water is evaporated to dryness and dried to a constant weight at 100° C. in an air bath. The residue is exhausted with 66 per cent. solution of 96 per cent. alcohol. This gives a residue containing $CaCO_3$, $MgCO_3$, $CaSO_4$, SiO_2, and a solution which contains the soluble salts of calcium, magnesium and sodium.

He had not had time to test this method in comparison with the scheme given in his paper, but said that it was a very useful method

for determining how the magnesium actually exists in the water, as the combination of the different bases and acids to represent their existing forms in solution in the water, is often a very hard question to decide.

Wm. G. Toplis, a well-known expert in the examination of drinking water, read a paper on "Some Refined Methods in Water Purification" (see page 116), which was illustrated with specimens of cultures, which he presented to the College. The paper elicited considerable discussion. In reply to a number of questions by Warren H. Poley, Mr. Toplis stated that there were hardly likely to be any bacteria growing in the service pipes, that the effluent waters from the filters contained as low as six bacteria per cubic centimetre, also that the number varied from fifteen to fifty as against the river water before entering the filter, which contained from 500 to 1,500, or even more organisms per cubic centimetre. Mr. Toplis spoke highly of the competency of the engineer corps connected with the filtering plant in Philadelphia, and thought that ultimately the citizens of Philadelphia would be proud of the finished work.

He also stated in reply to Mr. Poley that the magma formed by the addition of 1½ grains of alum to a gallon of water would remove even as much as 95 per cent. of the bacteria.

Mr. Toplis stated, in answer to a question by Mr. Kline, that the river-bottom sand is preferable to sand from other sources in that the particles of sand are already surrounded by the gelatinous envelope formed by bacteria, which is serviceable in the purification of water and so serves as a naturally prepared material for filtration purposes, thus saving time in the so-called ripening of the filter.

The subject of the origin of outbreaks of typhoid fever was discussed and in the main it was thought to be due to sewage contamination in water and milk. Professor Lowe spoke of an outbreak among the members of one of the fraternities at Yale University some years ago, which was traced to raw oysters which had been gathered in beds exposed to sewage contamination. Professor Kraemer referred to the fact that during the past summer he had an opportunity of visiting a number of the truck gardens in the vicinity of Philadelphia, and that the usual way of enriching the land was by the use of "privy manure," which is not infrequently collected in large pools on the farms. He stated that he thought that this might be a source of disease in certain cases, as the sewage

is brought in direct contact with the vegetables, as lettuce, celery, etc. He also alluded to the fact that it has been proved that certain bacteria even enter into the tissues through the stomata.

The next paper was one on "Methods and Interpretation of Water Analysis," by Dr. A. Robin, bacteriologist to the Water Department of Wilmington, Del. (See page 101.) The paper was illustrated with a number of cultures, one of which, *Bacillus violaceus*, he presented to the college. In the discussion of the paper afterwards Dr. Robin stated that in 1893 a semi-mechanical filter was built in Wilmington, Del., in which the oxidation was carried to an extreme, and in the same year a slow sand filter was established in Lawrence, Kan., where the water was also badly polluted. As proving the superiority of the slow sand filter the death-rate from typhoid in Lawrence has been reduced very considerably, whereas in Wilmington the rate has not diminished appreciably.

Professor Kraemer called attention to the fact that this was the third meeting in recent years at which there had been a discussion on the subject of water analysis. The first paper was by Dr. G. T. Moore, who had studied the subject of water contamination in Boston, and was entitled "Algæ as a Cause of the Contamination of Water" (see this JOURNAL, 1900, page 25); the second was by Mr. Toplis, on the "Filtration of Water" (see this JOURNAL, 1902, p. 67), and he said that on the present occasion we were fortunate in having a symposium on water analysis from a chemical and biological point of view, and moved that a vote of thanks be tendered the several speakers who contributed the papers, which motion was unanimously carried.

M. I. Wilbert, Ph.M., read some extracts from a quarterly review on "Progress in Pharmacy." (See page 129.)

The following provisional programme has been arranged for the next meeting:

"Aromatic Elixir," illustrated with samples, by Prof. Wilbur L. Scoville, Massachusetts College of Pharmacy.

"A Percolator Stand," by Harold Bertram Morgan, P.D.

"A Physician's Experience with Pharmacists," by Dr. Carl Freese, L.S.A.

Notes from Joseph Ince's book on "Elementary Dispensing," by M. I. Wilbert, Ph.M.

"Price Lists of Forty Years Ago," by William McIntyre, Ph.G.

HENRY KRAEMER, *Secretary.*

NOTES AND NEWS.

HEAVY LOSSES BY DRUG FIRMS.—The loss sustained by the drug trade of Baltimore as a result of the recent disastrous fire there, is estimated as not far short of $1,000,000. Various wholesale houses were burned out, and also a large number of retail stores, including the two leading ones in the city. The three leading wholesale firms whose properties were entirely destroyed, were Muth Brothers & Co., the Stanley & Brown Drug Company, and James Bailey & Son. These firms all had a large local patronage, and the loss has been seriously felt by the retail druggists of Baltimore. Fortunately, the large manufacturing firms of Sharp & Dohme, and Gilpin, Langdon & Co., were not reached by the fire, and these firms are able to carry on business as heretofore. The Baltimore branch of Parke, Davis & Co. was destroyed, the loss being $50,000.

THE ST. LOUIS EXPOSITION.—The list of European savants who have accepted invitations to deliver addresses at the International Congress of Arts and Science at the St. Louis Exhibition are the following: In Department 9 (Physics), Professor Dewar, the Royal Institution, London; M. Becquerel, member of the Institute of France. In Department 10 (Chemistry), Professor Moissan, Paris; Professor Fittig, Strassburg; Professor Van t'Hoff, Berlin; Professor Kossel, Heidelberg; Professor Mendelejeff, Technical School, St. Petersburg. In the biological section, the name appears of Professor Bower, of Glasgow, one of the examiners in Scotland to the Pharmaceutical Society.—*The Pharmaceutical Journal.*

THE SCIENTIFIC ATTITUDE IN EVERYDAY LIFE.—Prof. Francis E. Lloyd, of Teachers' College, Columbia University, in an address to the recent graduating class of Northwestern University, described the method of thought used by the scientist, and showed that this method is used by all of us in everyday life; that it is the method which we use as children. When used by the scientist, it comes under careful scrutiny and control. We therefore see the meaning of Huxley's statement that the method of the scientist is refined common sense. All studies may be prosecuted by this method, since it is common to all. Any advantages which one study may offer beyond another must be due to its subject matter

The strict application of the scientific method makes for ideals in life and character, since it enforces upon the mind standards of honesty which are of the highest, and are impersonal. Those who have had the advantage of scientific training, should see clearly that they are under the obligation to carry the ideals thus gained into their everyday lives.

The pharmacist, who stands in a peculiar relation to human life, must have, with the physician, the same impersonal attitude. His scientific training should bring him to recognize this obligation. The oath of Hippocrates, which binds the physician to do no mischief, is binding also upon the pharmacist, who shares the responsibility of the physician.